In the Specification:

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The technology for watermarking digital images is well developed. The intensity of the watermark determines both if the watermark will create visual artifacts and how easily the watermark will be to detect after an image has been printed, copied or otherwise transformed. When inserting a digital watermark[~~ing~~] into an image, it is desirable to utilize a high intensity watermark signal, that is, to change the intensity of the pixels in the image as much as possible so that it will be easy to detect and read the watermark. However, if the intensity of the watermark signal is too high, the watermark may create visual artifacts in the image, that is, the watermark signal may be visually evident.

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Many watermarking technique are "perceptually adaptive". Perceptually adaptive watermarking techniques take into account the characteristics of an image in an effort to make a watermark relatively easy to detect and to avoid causing visually apparent artifacts in the watermarked image.[~~-~~]

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In the first preferred embodiment, the invention is applied to an [~~a~~] image which consists of a series of lines. Images which consist of a series of lines [~~line~~] are, for example, often found as [~~a~~] background imagery on security documents and on currency. A digital watermark can be inserted into such an image using line width modulation techniques such as those shown in co-pending US patent applications 09/074,034, filed May 6, 1998 which corresponds PCT/US99/08252, and 09/127,503, filed July 31, 1998 which corresponds to PCT/US99/14532. The disclosures of the above referenced patent applications is incorporated herein in their entireties

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However, with the present invention, when changing the pixels in the image in accordance with the payload tile, an additional intensity factor is taken into account. For example, in a particular

square on the grid, the pixels in the square may only be changed by one half of the amount specified in the payload tile. In another square on the grid,[-] the pixels may be changed by seventy five percent of the amounts specified in the payload tile. That is, a watermark can be inserted into the image by changing each pixel in the image by an amount specified by an associated pixel in a payload tile, as modified by an intensity factor. The intensity factor for each pixel in the image is specified using the previously described masks which define an appropriate intensity for different areas of the image.

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The masks are ordered (with the mask specifying areas with the least intensity first) and if two masks have images at the same location, the first mask in the series controls the intensity of the pixels. The payload tile includes a value for each pixel in a square on the image. Each pixel in each square of the image is changed by an amount that depends both on the value specified by the associated pixel in the payload tile and by the various masks that define areas of the image to be watermarked at various intensities. The intensity that should be associated with a mask for an area having a particular width index can be determined by trial and error. However, once determined, this value can be used for subsequent operations. That is, [~~while~~] the shape of the masks for different images will vary according to the characteristics of the image. The intensity value assigned to a mask which represents an area having a particular width index can be the same for different images.

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A system for performing the above described operations is shown in Figure 4. The system includes a conventional personal computer system 401. This can for example be an [a] Intel Pentium III system operating under the Microsoft Windows operating system. The computer system 401 includes conventional I-O devices such as a display, a keyboard, a printer, etc, conventional storage devices such as RAM, hard drive, CD drive etc. Such conventional components are not shown in Figure 4.

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The system includes an image [~~edition~~] editing program 403 such as for example the Adobe Photoshop image editing program. The image editing program 403 includes [~~a~~] an image watermarking facility 405, an image filtering facility 407, and an [~~Image~~] image addition and subtraction facility 408. Except for the details described herein, the image editing program 403, the watermarking facility 405, the filtering facility 407, and the image addition and subtraction facility 408 are [~~standard~~] conventional components.

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The embodiment of the invention described above applied a watermark to an image that consisted of a series of lines with different width. The embodiment of the invention described below applies the invention to a half tone image such as that shown in Figure 5. The half tone image shown in Figure 5 is a conventional halftone image. It can, for example, be a single color channel of a multicolor image.

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Halftone images such as image 500 that are shown in Figure 5 can be transformed into line art images such as line art image 601 shown in Figure 6. This conversion can be done by conventional, well knows processes regularly used in the printing industry. After a half tone image such as image 500 shown in Figure 5 is converted to a line art image such as image 601 shown in Figure 6, the invention can be applied as previously explained with respect to the first embodiment of the invention. That is, image 601 shown in Figure 6 can be divided into areas, each of which has lines the width of which falls in a particular range.

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The line art image 601 shown in Figure 6 appears as a series of lines. As is well known in the printing art, the elements in a line art image need not be lines. The elements in the line art image can be circles as in image 701 shown in Figure 7. The particular shape of the elements is generally selected for various esthetic reasons and the present invention can be used with elements having any desired shape. The filtering to define areas having the same tonal density

would proceed as previously described irrespective of the shape of the elements in the line art image.

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The first division of the pixels or bits is into areas that are identical in size. That is, the first division divides the pixels into areas each of which is the size of the payload tile. The payload tile specifies the change in each bit or pixel in an area the size of said payload tile. The amount specified by the values in said payload tile is the amount which is appropriate for the watermark to carry the desired payload data. The values in the payload tile can be established and used on a perceptually adaptive basis.